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(54) **TOWED SCRAPER BLADE CONTROL METHOD**

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(51) **Int. Cl.**
A01B 79/00 (2006.01)
E02F 3/76 (2006.01)

(52) **U.S. Cl.** **172/1**; 172/4.5

(58) **Field of Classification Search** 172/1, 172/2, 4.5, 7, 8, 10, 11, 12, 684.5; 37/348
See application file for complete search history.

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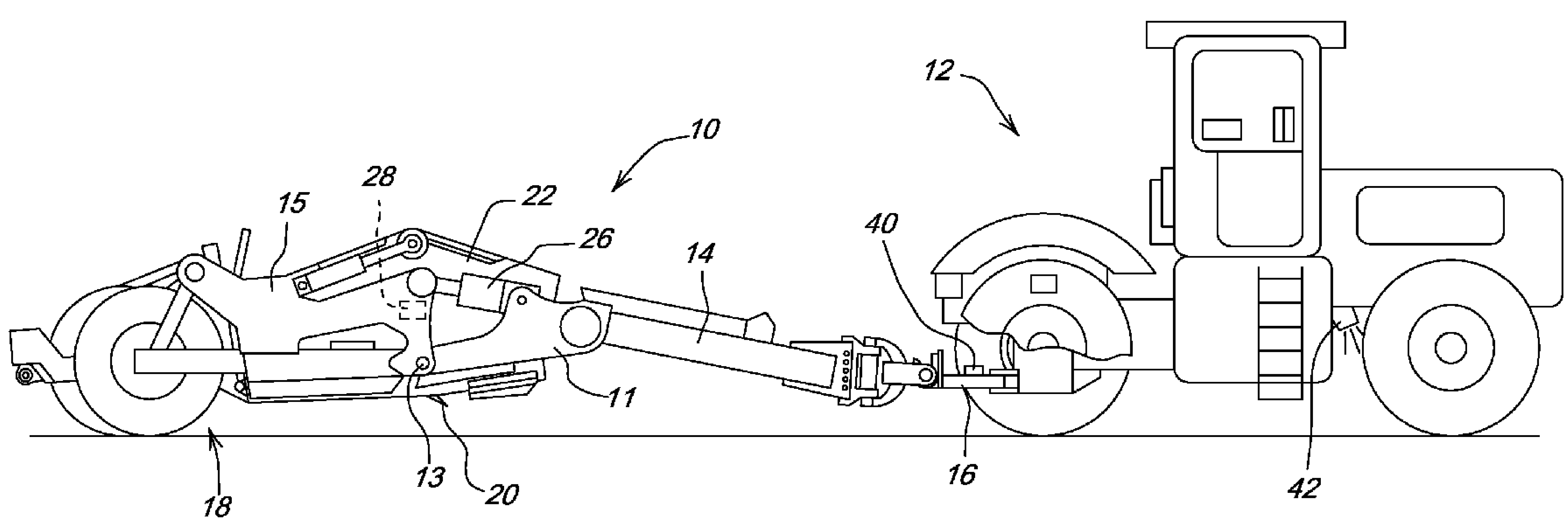
(57) **ABSTRACT**

A towed scraper control system automatically lowers the scraper blade to a working position at the start of a scraping operation according to a certain method. The method includes sensing a ground speed of the vehicle and sensing a draft force applied by the scraper to the vehicle. With the vehicle pulling the scraper at or near a target ground speed over terrain with the blade positioned above a surface of the ground, the blade is automatically lowered with respect to the scraper frame at a first rate until the blade begins to engage the surface of the ground. Thereafter, while the vehicle continues to move forward at or near the target ground speed, the blade is lowered with respect to the frame at a second rate and for a duration related to the sensed ground speed so that lowering of the blade stops when the scraper wheel begins to enter a cut produced by the blade. With the blade fixed with respect to the scraper frame, the scraper is moved forward at the target ground speed for a distance determined as a function of the sensed draft force. Thereafter, the blade is raised with respect to the frame at a rate which matches a lowering rate of the wheels as they descend along the cut, and the blade is raised at this matching rate until the position of the blade matches the position of the blade after the first lowering step. Preferably, the second rate is slower than the first rate.

8 Claims, 5 Drawing Sheets



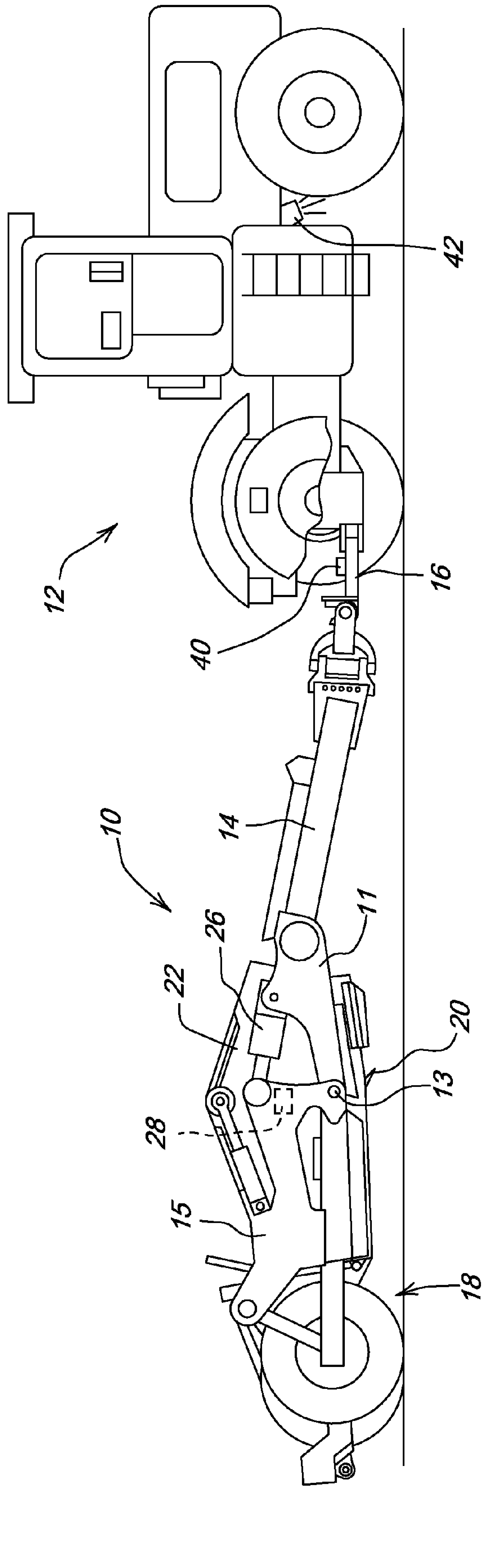


Fig. 1

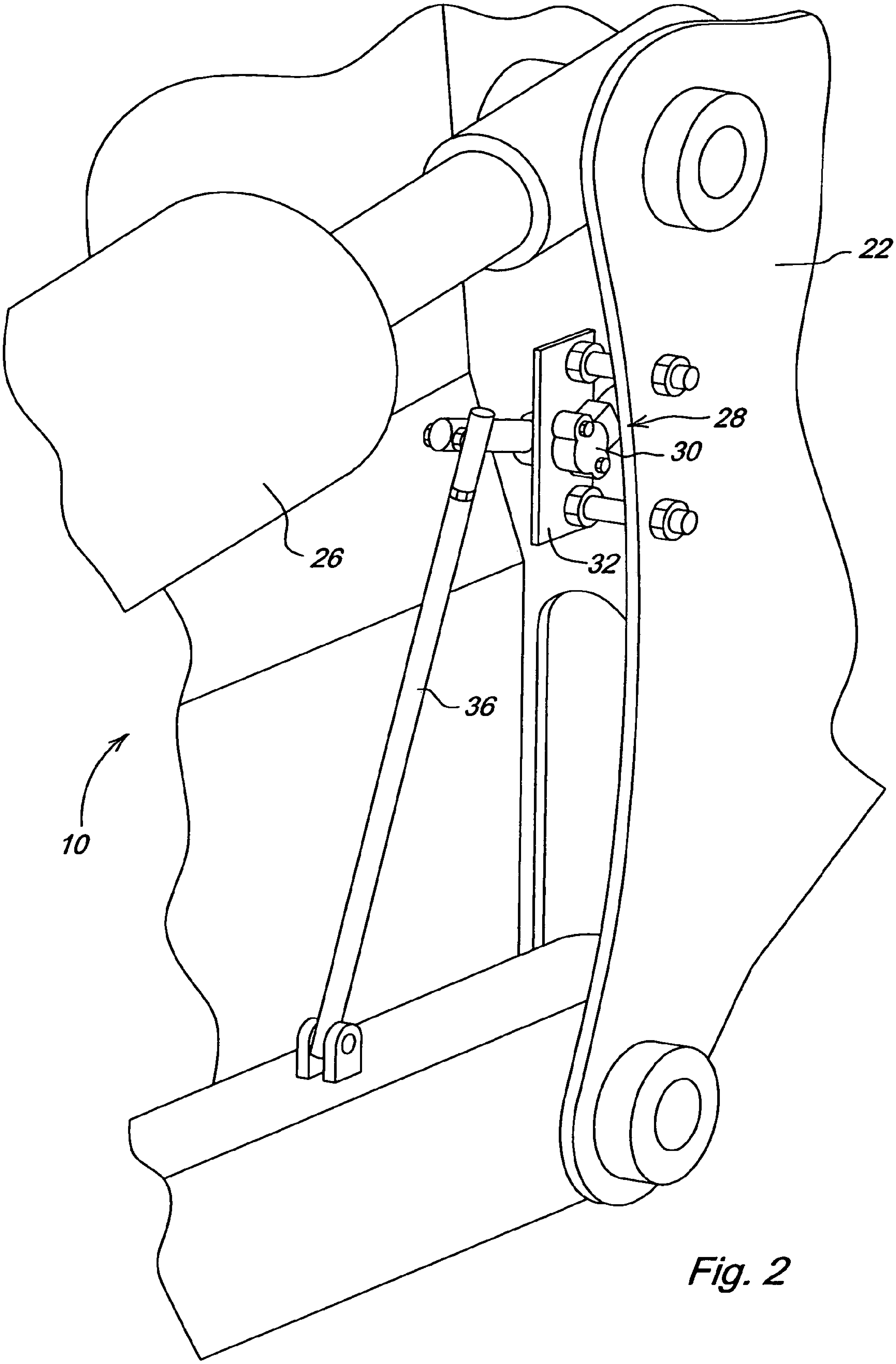


Fig. 2

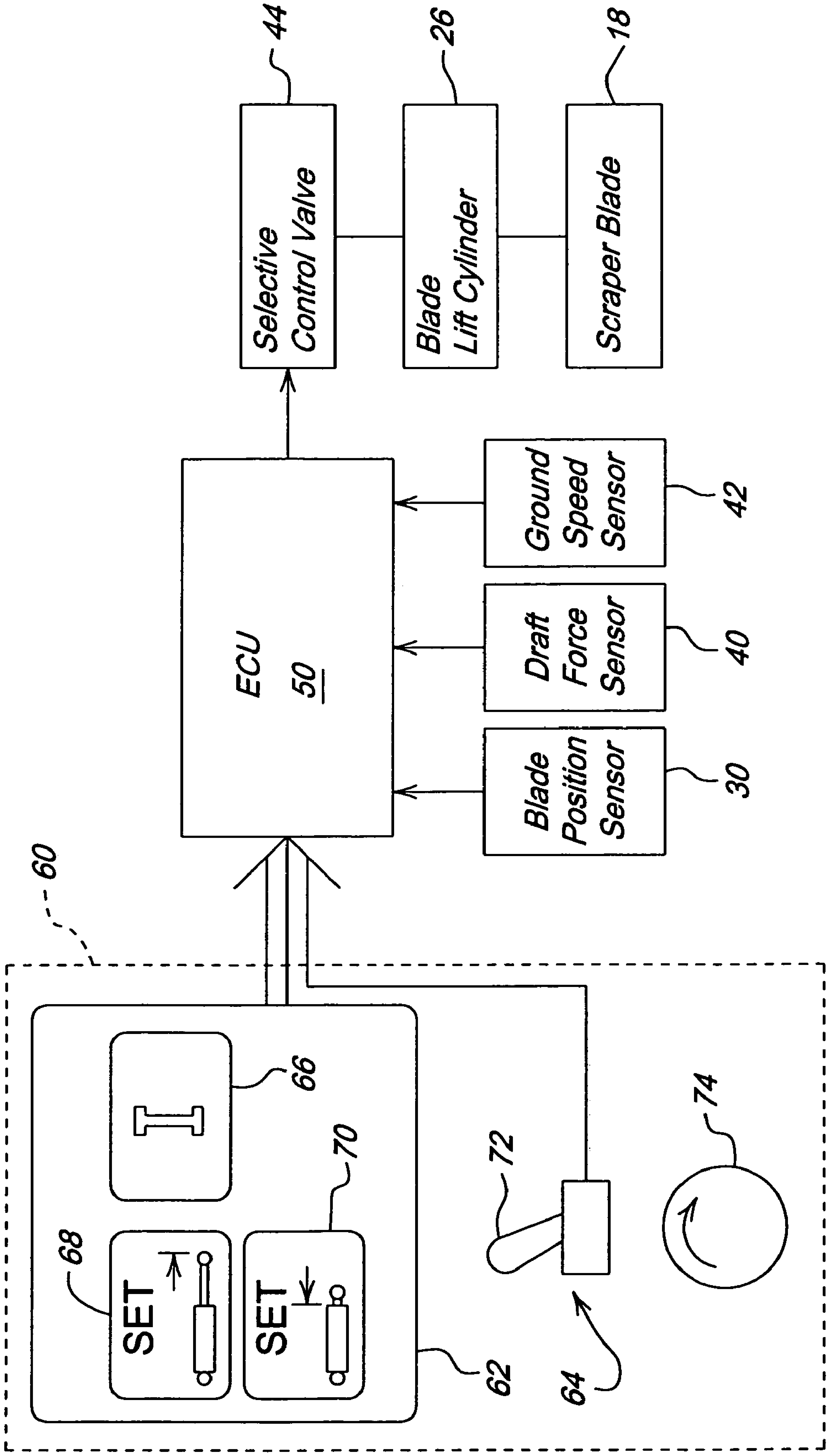

Selective Control Valve
44
Blade Lift Cylinder
26
Scraper Blade
18
ECU
50
Ground Speed Sensor
42
Draft Force Sensor
40
Blade Position Sensor
30
60
66
70
68
SET
SET
72
74
62
64

Fig. 3

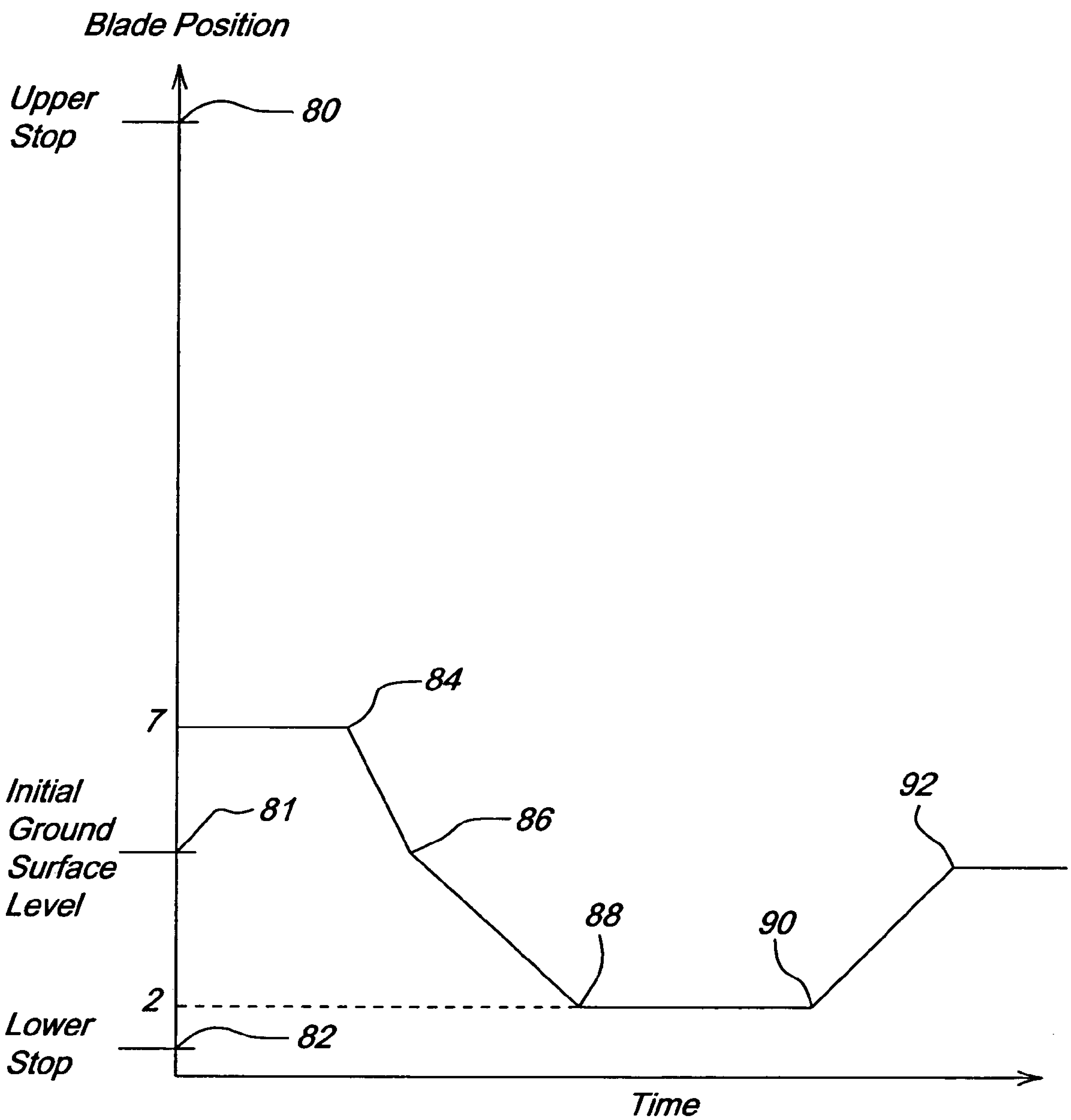

Blade Position
Upper Stop
80
7
84
Initial Ground Surface Level
81
86
92
88
90
2
Lower Stop
82
Time

Fig. 4

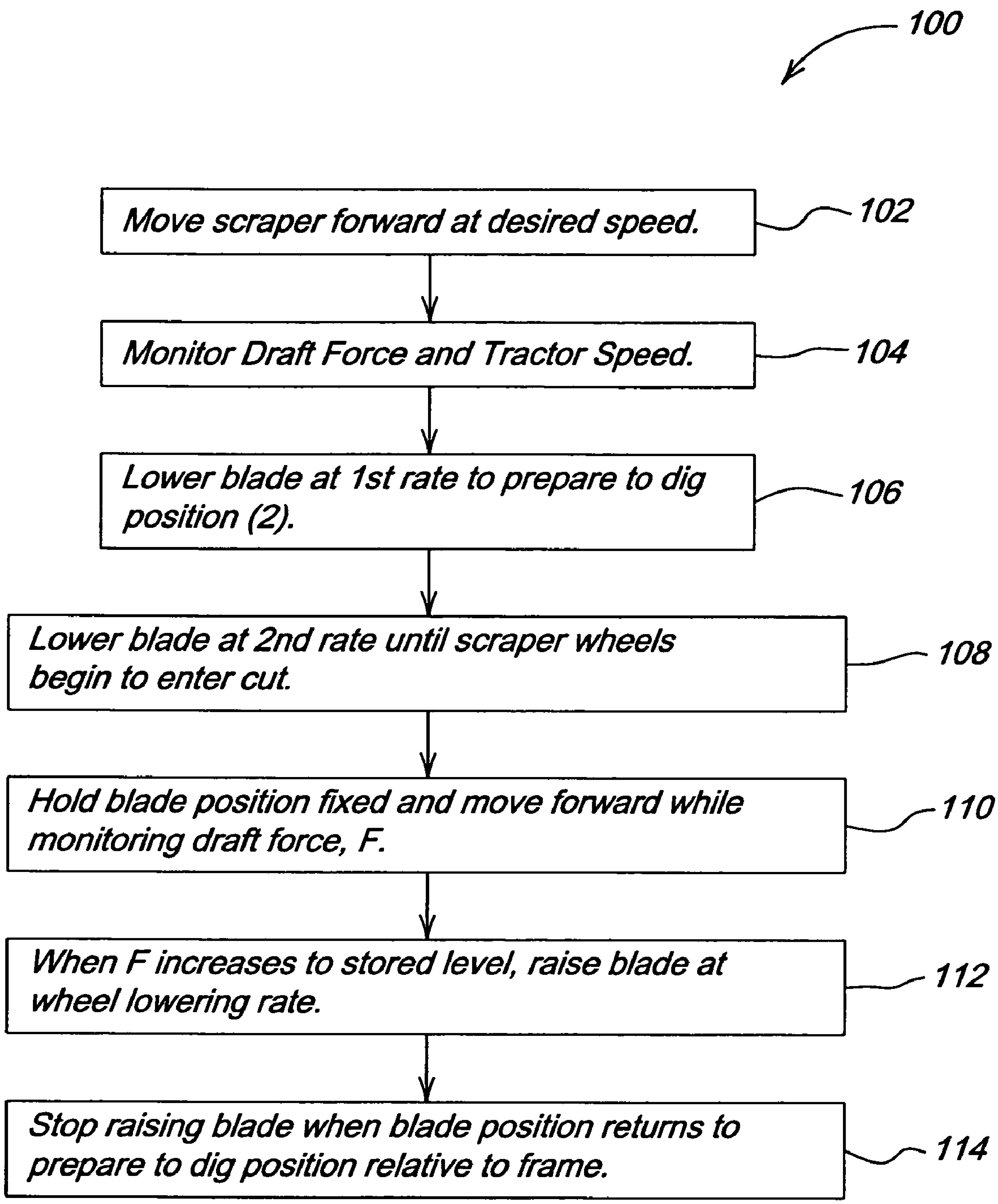

100
Move scraper forward at desired speed.
102
Monitor Draft Force and Tractor Speed.
104
Lower blade at 1st rate to prepare to dig position (2).
106
Lower blade at 2nd rate until scraper wheels begin to enter cut.
108
Hold blade position fixed and move forward while monitoring draft force, F.
110
When F increases to stored level, raise blade at wheel lowering rate.
112
Stop raising blade when blade position returns to prepare to dig position relative to frame.
114

Fig. 5

TOWED SCRAPER BLADE CONTROL METHOD

BACKGROUND

The present invention relates to a method of controlling the blade of a towed scraper pulled by a towing vehicle, such as a tractor.

With a tractor drawn scraper the depth of cut of the scraper is manually controlled by an operator as the machine traverses the ground. To obtain maximum operating efficiency, experienced operators will feather the depth of cut to prevent clutching, tractor stall or wheel slip during use. It is often difficult for an operator to properly adjust blade position or depth at the start of a scraping operation. These tasks require an operator with considerable experience and skill and a high level of concentration to operate at an acceptable level of productivity and performance. It would be desirable to have a control system which, at the start of a towed scraper operation, can automatically, quickly and accurately move the scraper blade to its proper desired working depth.

SUMMARY

Accordingly, an object of this invention is to provide a method of automatically lowering the blade of a towed scraper to a working position.

A further object of the invention is to provide such a method which, at the start of a towed scraper operation, will quickly and accurately move the scraper blade to its proper desired working depth.

These and other objects are achieved by the present invention, wherein a control system automatically moves the blade of a towed scraper to a desired working position. The control system includes a position sensor which provides a signal proportional to the position of the scraper cutting edge relative to the scraper chassis, and a draft sensor which provides a signal proportional to the draft load exerted by the scraper on the tractor drawbar. An electronic controller receives the sensor signals, operator commands, and various signals from the tractor system. The electronic controller stores blade position setpoints, monitors the operator controls, and monitors various parameters, such as the engine rpm, transmission gear, ground speed, etc. The electronic controller moves the scraper blade to preset positions, and automatically moves the blade from a pre-dig position to a working or digging position as a scraping operation is begun under a desired method.

The method includes sensing the ground speed of the vehicle, sensing a draft force applied by the scraper to the vehicle, and with the vehicle pulling the scraper at a target measurable ground speed with the blade positioned above the surface of the ground, automatically lowering the blade with respect to the front frame at a first rate until the blade begins to engage the surface of the ground. Thereafter, while the vehicle continues to move forward at near the target ground speed, the blade is lowered at a second rate and for a duration related to the sensed ground speed so that lowering of the blade stops when the scraper wheels begin to enter the cut produced by the blade. With the blade position fixed, the scraper is moved forward at near the target ground speed for a distance determined as a function of the sensed draft force. Thereafter, the blade is raised until the position of the blade relative to the front frame matches the position of the blade relative to the front frame at the end of the first lowering step.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a simplified side view of a scraper pulled by a tractor;

FIG. **2** is a perspective view of a blade position sensor which is mounted on the scraper of FIG. **1**;

FIG. **3** is a schematic block diagram of the control system of the present invention;

FIG. **4** is blade position versus time diagram which illustrates the blade lowering method of the present invention; and

FIG. **5** is logic flow diagram illustrating the blade lowering method of the present invention.

DETAILED DESCRIPTION

Referring to FIG. **1**, a pull-type scraper **10** is towed by a towing vehicle, such as a conventional tractor **12**. The scraper **10** is preferably a conventional commercially scraper, such as a John Deere model 1810 fixed-blade ejector scraper. Such a scraper **10** includes a relatively fixed front frame **11** attached to a forward extending tongue **14** which is coupled to a drawbar **16** of the tractor **10**. The scraper **10** also includes a rear frame **15** which has an aft end supported by ground engaging wheels **18** and which is pivotally coupled to the front frame **11** at pivot **13**. The scraper **10** also includes a blade **20** which projects from the bottom of a gate **22** which is fixed relative to rear frame structure **15**.

The gate **22** and the blade **20** are raised and lowered by blade lift cylinders **26**. A blade position sensor **28** on the scraper **10** senses the position or angle of the blade **20** with respect to the front frame **11**. A draft force sensor **40** is preferably mounted on a upper surface of the conventional tractor drawbar **16**. The draft force sensor **40** is preferably a strain gauge type force sensor with a T-rosette configuration, similar to a Series 460 bolt-on strain gauge which is commercially available from Datum Electronics Limited. Alternatively, the draft force sensor could be mounted in an appropriate location on the scraper tongue **14**.

As best seen in FIG. **2**, the blade position sensor unit **28** includes a rotary position sensor **30** mounted on a plate **32** which is fixed to a part of the rear frame **15**. A sensing arm **34** projects from the sensor **30**, and a rod **36** connects the arm to a part (not shown) of the front frame **11**. As the blade **20** and gate structure **22** move with respect to the front frame **11**, the rod **36** pivots arm **34** which in turn imparts a rotary input to sensor **30**. The blade **20** will be raised when cylinder **26** is extended and lowered when cylinder **26** is retracted. A vehicle speed sensor **42**, such as a commercially available radar speed sensing unit, is mounted on the tractor **12**.

Referring now to FIG. **3**, a control system includes a microprocessor based electronic control unit (ECU) **50** which receives a blade position signal P from sensor **30**, a draft force signal F from sensor **40** and a vehicle or ground speed signal S from sensor **42**. ECU **50** also receives signals from operator controls **60** which includes a touch panel control unit **62** and a selective control valve control lever unit **64**, both of which are commercially available on production John Deere tractors. The touch panel control unit **62** includes a SCV (selective control valve) select button **66**, an upper set point setting button **68** and a lower set point setting button **70**. The commercially available SCV control lever **64** includes a lever **72** which is movable back and forth to cause SCV I to extend (raise) and retract (lower) the lift cylinder **26**, is movable to a to a detent position, and is movable fully forward to float position. The operator controls **60** also include a rotary draft force or aggressiveness setting knob **74** so the operator can set a desired operating draft force or aggressiveness value F(desired), which the ECU **50** automatically adjusts depending upon the operating gear ratio and speed to compensate for the fact that at higher gear ratios the tractor **12** is limited in the amount of draft force or pulling force it can handle. The ECU **50** provides a valve control signal VC to the SCV **44**. SCV **44** is connected by hydraulic lines to the lift cylinders **26**. SCV **44** controls communication between lift cylinders **26** a conventional pump (not shown) and a conventional reservoir (not shown).

The ECU **50** is preferably programmed to perform the automatic blade lowering method illustrated by FIGS. **4** and **5**. The conversion of the above flow chart of FIG. **5** into a standard language for implementing the algorithm described by the flow chart in a digital computer or microprocessor, will be evident to one with ordinary skill in the art.

Referring to FIG. **4**, the scraper blade **20** can be raised and lowered between an upper mechanical stop position **80** and a lower mechanical stop position **82**, relative to the front frame **11**. Line **81** represents an original ground surface level before the blade **20** has entered the ground. In a typical scraper of this type positions **80** and **82** may be as much as 28 inches apart.

Before this method is performed, the following steps are performed by an operator while the scraper **10** and tractor **12** are stationary. First, button **66** is pressed so that future inputs of the blade position signal P from sensor **30** and buttons **68** and **70** will be associated with and stored in connection with the operation of SCV **44**. Then lever **72** is move back to a rearward position, thus raising the blade **20** to a desired raised position, whereupon upper set point button **68** is pressed to cause the ECU **50** to store the current signal from position sensor **30** as an upper position set point value, at or near position **80** of FIG. **4**.

Lever **72** is then manipulated to cause SCV **44** to retract cylinder **26** and lower the blade **20** to a position just above and not engaging the surface of the ground, whereupon button **70** is pressed to store the current position from sensor **30** as a prepare to dig position set point value, corresponding to position **7** of FIG. **4**.

Lever **72** is then manipulated to cause SCV **44** to lower the blade **20** slightly into the ground, and lever **72** is moved fully forward to its float position. Button **70** is then pressed to cause the ECU to store a working position set point value Pw **81**. Lever **72** is then moved full back to the detented position and released and the ECU **50** will raise the blade to its upper set point position, at or near position **80** of FIG. **4**.

Next, the tractor transmission (not shown) is placed in a working speed gear and the throttle (not shown) is moved fully forward so that the tractor **12** will move forward at the desired working speed.

Lever **72** is then pushed forward to its detent position and released. The ECU is programmed to automatically lower the blade **20** to the previously stored prepare to dig position (**84** of FIG. **4**). Lever **64** is then pushed forward again to its detent position and released. This start command will cause the ECU to automatically execute, according to the present invention, the method **100** of lowering the blade **20** to start a cutting operation while the scraper **10** and tractor **12** continue to move forward.

Referring to FIGS. **4** and **5**, during the execution of this method, the tractor **12** pulls the scraper **10** at a selected target ground speed (step **102**) over terrain with the blade **20** positioned at the preset prepare to dig position **84**, and the ECU **50** monitors the tractor ground speed from sensor **42** and monitors the sensed draft force from sensor **40** (step **104**). In response to a start command from the operator, the ECU **50** automatically causes cylinder **26** to lower the blade **20** at a first rate (step **106**) until the blade **20** begins to engage the surface of the ground or reaches the working position **86** of FIG. **4**. It should be understood that the ground speed will decrease slightly as the blade **20** engages the ground and increases the draft force applied to the tractor while the tractor engine and transmission control systems attempt to keep the tractor moving at the target ground speed.

Thereafter, while the scraper **10** continues to move forward at near the target ground speed, the blade **20** is lowered at a second rate (with respect to frame **11**) and for a duration related to the sensed ground speed so that lowering of the blade **20** stops when the scraper wheel **18** begins to enter the cut produced by the blade **20** traveling through the ground (step **108**). The ECU **50** determines this by integrating the ground speed to obtain the distance traveled and comparing the distance traveled to the stored distance between the blade **20** and the wheels **18**. The second lowering rate is preferably slower than the first lowering rate. When the wheels **18** begin to enter the cut, lowering of the blade **20** is stopped as the scraper **10** continues to move forward, whereupon the position of the blade **20** relative to frame **11** is represented by position **88** of FIG. **4**.

With the blade **20** fixed with respect to the scraper frame **11**, the scraper **10** is pulled forward at the desired ground speed (step **110**) while the sensed draft force is monitored and compared to a stored draft force level which is a predetermined percentage of the draft force parameter set by the operator with knob **74**. The draft force will be increasing because the blade **20** will be moving downward with respect to the surface of the ground (but fixed with respect to front frame **11**).

When the sensed draft force increases to this stored draft force level (position **90** of FIG. **4**), the ECU **50** automatically causes the blade **20** to raise (step **112**) with respect to the frame **11**, preferably at a raising rate which is the same as the rate at which the wheels **18** are lowering as they descend along the cut produced by the blade **20** moving through the ground. Thus, the scraper will travel forward with the depth of blade **20** substantially fixed with respect to the ground. The ECU **50** will continue to raise the blade **20** with respect to the front frame **11** at this rate until the position of the blade **20** relative to the frame **11** reaches position **92** of FIG. **4**, which will normally matches the position of the blade relative to the frame **11** represented by position **86** of FIG. **4**, whereupon the ECU **50** will stop raising the blade **20** (step **114**). But, because the scraper wheels **18** are down in the cut, the blade **20** will be at some working position below the surface of the ground. This working position will generate a draft force approximately equal to the stored draft force level set by the operator with knob **74**.

The scraper **10** is thereafter continued to be pulled forward by the tractor **12** at the desired working speed while the position of the blade **20** remains fixed with respect to scraper frame **11**. The position of the blade **20** may be thereafter controlled in a closed loop manner in response to sensed draft force, engine speed and other parameters as is well known in the implement draft control field.

A similar blade lowering method could be applicable in a tandem towed scraper arrangement (not shown) where two scrapers are towed, one behind the other. Normally, when the front scraper is filled, its blade is lifted and the rear scraper blade then-continues the same cut as its blade reaches the end of the cut made by the front scraper. In the case of the rear scraper, the lowering of its blade at the second rate would be delayed until the blade of the rear scraper engages the ramp of soil left at the point where the blade of the front scraper was lifted.

While the present invention has been described in conjunction with a specific embodiment, it is understood that many alternatives, modifications and variations will be apparent to those skilled in the art in light of the foregoing description. Accordingly, this invention is intended to embrace all such alternatives, modifications and variations which fall within the spirit and scope of the appended claims.

We claim:

1. A blade lowering method for a towed scraper pulled over ground by a towing vehicle, the scraper having a front frame coupled to the towing vehicle, a rear frame, ground engaging wheels supported from the rear frame and a blade movable with respect to the front frame, the method comprising:

a) sensing the ground speed of the vehicle;

b) sensing a draft force applied by the scraper to the vehicle;

c) with the vehicle pulling the scraper at a target ground speed with the blade positioned above a surface of the ground, automatically lowering the blade with respect to the front frame at a first rate until the blade begins to engage the surface of the ground;

d) thereafter, while the vehicle continues to move forward at or near the target ground speed, lowering the blade with respect to the front frame at a second rate and for a duration related to the sensed ground speed so that lowering of the blade stops when the scraper wheels begin to enter a cut produced by the blade;

e) with the blade fixed with respect to the front frame, moving the scraper forward at or near the target ground speed for a distance determined as a function of the sensed draft force; and

f) thereafter raising the blade with respect to the front frame until the position of the blade relative to the front frame matches the position of the blade relative to the front frame at the end of step c).

2. The method of claim **1**, wherein:

the second rate is slower than the first rate.

3. The method of claim **1**, wherein:

the blade is raised with respect to the front frame at a matching rate which matches a lowering rate of the wheels as they descend along the cut.

4. The method of claim **1**, wherein:

the blade is lowered at said second rate immediately upon termination of blade lowering at said first rate.

5. A blade lowering method for a towed scraper pulled over ground by a towing vehicle, the scraper having a front frame coupled to the towing vehicle, a rear frame, ground engaging wheels supported from a rear end of the rear frame and a blade movable with respect to the front frame, the method comprising:

a) sensing the ground speed of the vehicle;

b) sensing a draft force applied by the scraper to the vehicle;

c) with the vehicle pulling the scraper at a target ground speed with the blade positioned above a surface of the ground, automatically lowering the blade with respect to the front frame at a first rate until the blade begins to engage the surface of the ground;

d) thereafter, while the vehicle continues to move forward at or near the target ground speed, lowering the blade with respect to the front frame at a second rate;

e) stopping lowering of the blade at said second rate when the scraper wheels begin to enter a cut produced by the blade;

f) while continuing to move the scraper forward at or near the target ground speed, holding the blade fixed with respect to the front frame so that the blade moves downward with respect to the ground as the scraper descends along the cut, until the sensed draft force increases to a preset draft force; and

g) when the sensed draft force matches the preset draft force, raising the blade with respect to the front frame until the position of the blade relative to the front frame matches the position of the blade relative to the front frame at the end of step c).

6. The method of claim **5**, wherein:

the blade is raised with respect to the front frame at a matching rate which matches a lowering rate of the wheels as they descend along the cut.

7. The method of claim **5**, wherein:

the blade is lowered at said second rate immediately upon termination of blade lowering at said first rate.

8. A blade lowering method for a towed scraper pulled over ground by a towing vehicle, the scraper having a front frame coupled to the towing vehicle, a rear frame, ground engaging wheels supported from a rear end of the rear frame and a blade movable with respect to the front frame, the method comprising:

a) sensing the ground speed of the vehicle;

b) sensing a draft force applied by the scraper to the vehicle;

c) with the vehicle pulling the scraper at a target ground speed with the blade positioned above a surface of the ground, automatically lowering the blade with respect to the front frame until the blade begins to engage the surface of the ground;

d) thereafter, while the vehicle continues to move forward at or near the target ground speed, further lowering the blade with respect to the front frame;

e) when the scraper wheels begin to enter a cut produced by the blade, holding the blade fixed with respect to the front frame;

f) with the blade fixed with respect to the scraper frame, moving the scraper forward at or near the target ground speed for a distance determined as a function of the sensed draft force; and

g) thereafter raising the blade with respect to the frame at a rate which matches a lowering rate of the wheels as they descend along the cut, and raising the blade at said matching rate until the position of the blade relative to the frame matches the position of the blade relative to the frame at the end of step c).

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